

Towards Understanding and Quantifying Subgrid-Scale Processes for Global Aerosol Modeling

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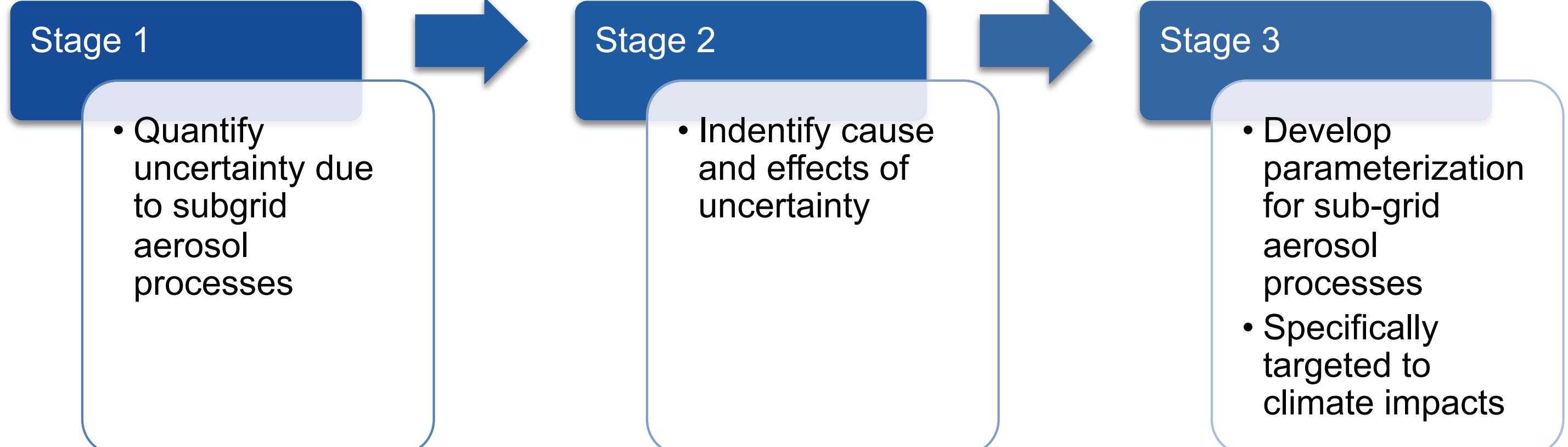
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The need for understanding subgrid-scale impacts on aerosols in climate models

Decades of work has gone into understanding subgrid-scale processes on clouds and turbulence, but much less effort has gone into understanding subgrid processes on aerosols, which also have important climate influences. Many of the traditional subgrid processes affecting meteorology also affect aerosols, with the addition of aerosol specific processes. Examples include:

- Clouds affecting transport, radiation, and aqueous chemistry
- Turbulence
- Trace gas and aerosol emissions
- Nonlinearity of chemical reactions
- Aerosol mixing states, e.g. internal vs. external mixtures

Project Overview



We are in the first year of a multi-year effort to both quantify and develop parameterizations to address deficiencies in global models related to subgrid aerosols processes.

Stage 1 model simulations focus on the MILAGRO field campaign in Mexico during March 2006 using the WRF-Chem model. A high resolution domain represents the neglected subgrid processes compared to a GCM-like resolution domain.

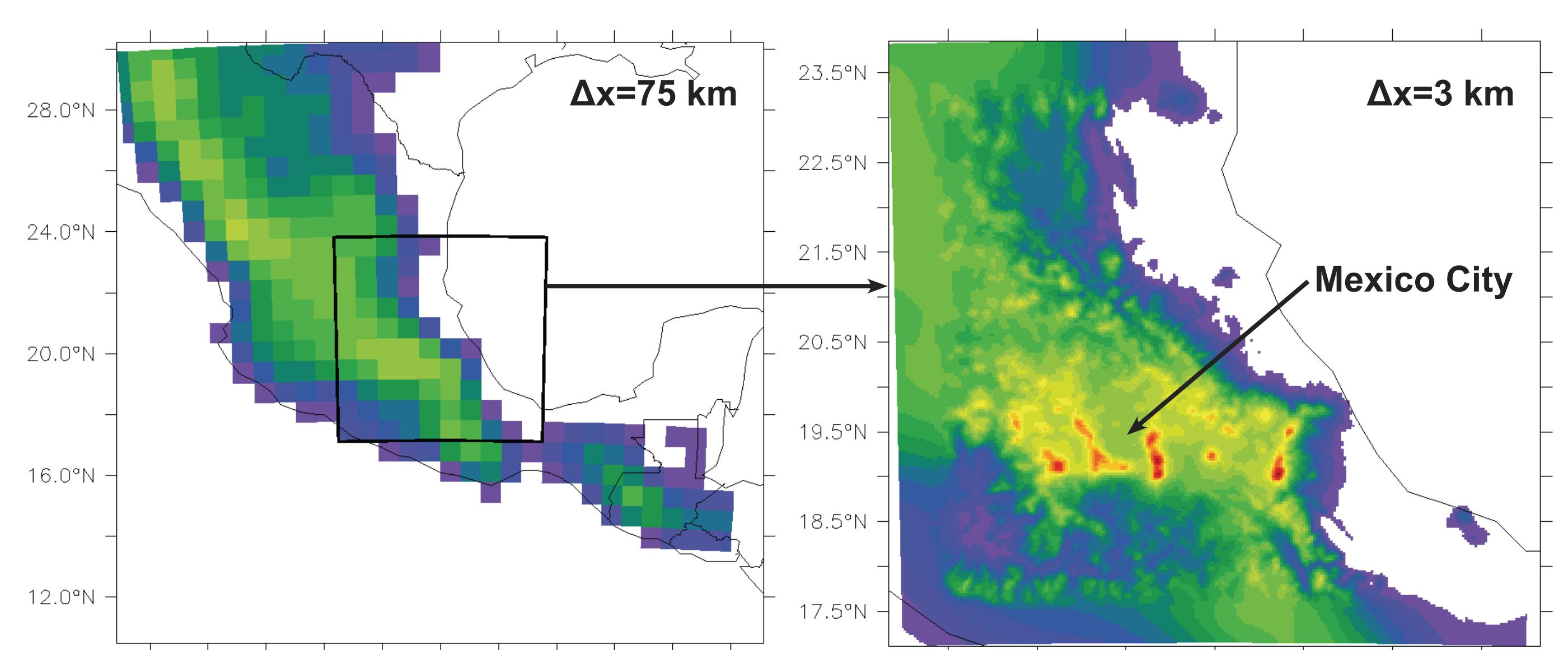


Figure 1. Terrain height for outer ($\Delta x=75$ km) and inner ($\Delta x=3$ km) domains. The grid edges are coaligned between the domains to facilitate inter-domain comparisons. The inner region has the same lateral boundary conditions for both domains.

High resolution leads to more variability

As expected, the higher resolution domain generates more variability in the aerosol signal. But is the solution more accurate?

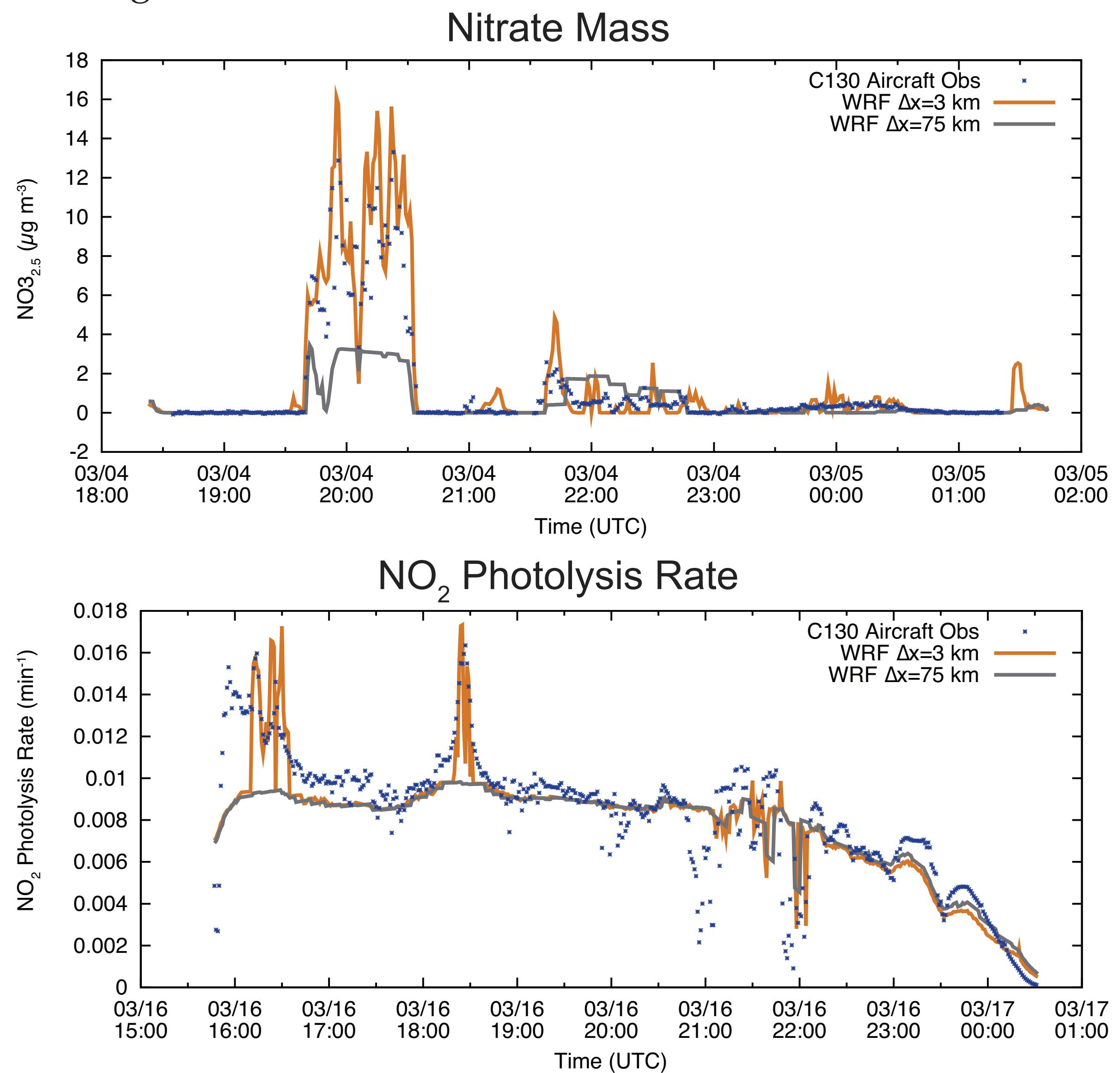


Figure 2. Comparison of the low and high resolution domains showing the high resolution domain capturing specific plumes more accurately compared to C130 aircraft observations.

How different is the high-resolution domain when compared at the GCM scale?

Neglect of subscale processes leads to important differences between the high and low-resolution domains when compared at the coarse scale.

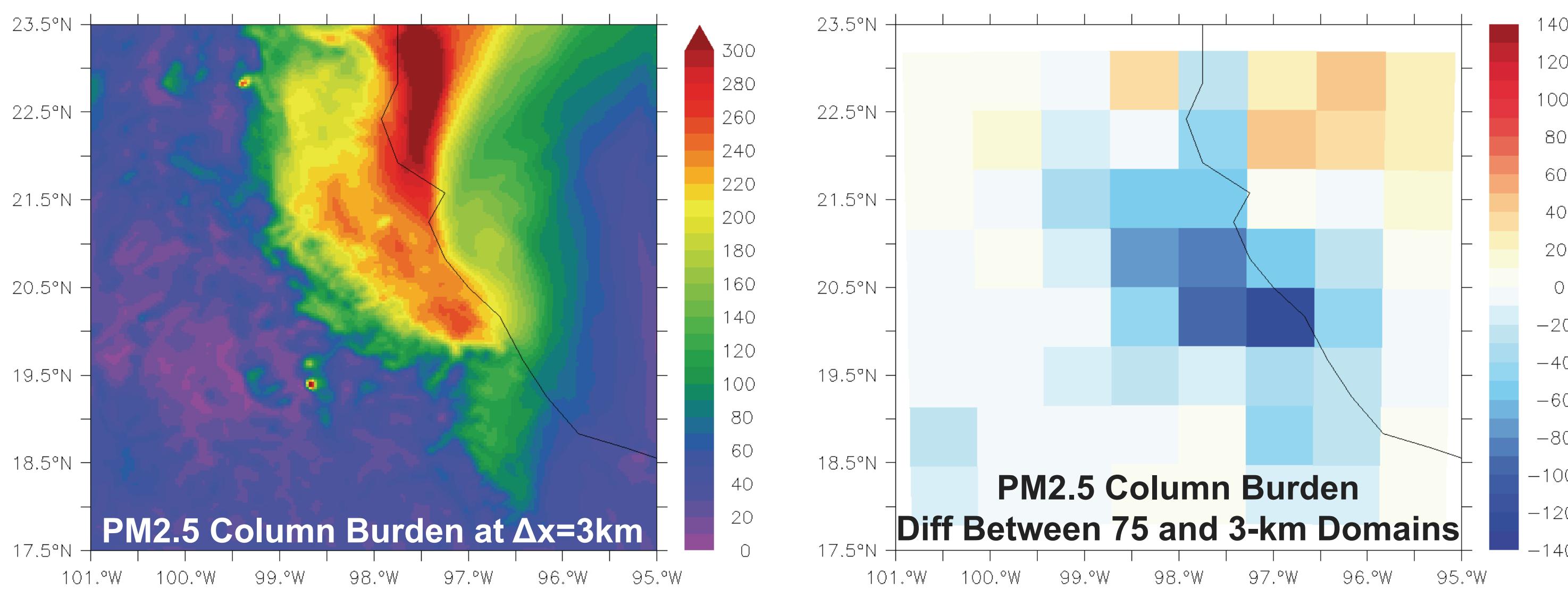


Figure 3. $PM_{2.5}$ column burden ($mg\ m^{-2}$) for 11 Mar 2006 19 UTC from the 3-km domain and the difference between 75 and 3-km domains. The 3-km domain is regressed to the 75-km domain for the difference comparison. The increased detail in the 3-km domain does not average back to the coarse value, implying different climate forcing impacts.

Quantifying Neglected Subgrid Processes

The normalized mean bias factor (NMBF) is a useful tool for quantifying differences between the 75 km and regridded 3 km domains. For initial comparisons, cloudy regions are excluded implying that the differences shown are smaller than in reality since clouds are a strong subgrid influence. Secondary organic aerosol production is also not included.

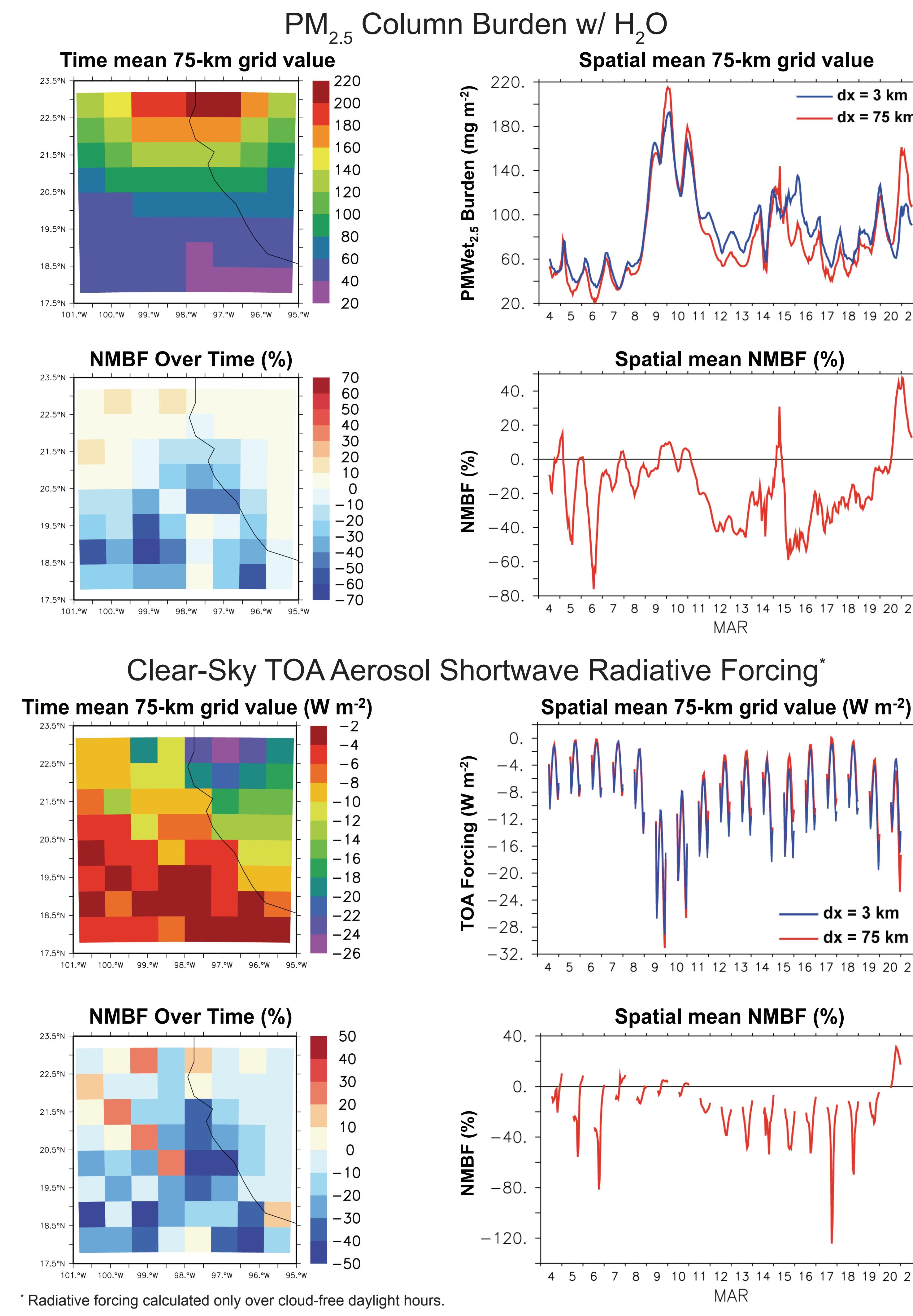


Figure 4. Comparisons of time and spatial mean values alongside averaged normalized mean bias factors showing the potential impact of neglected subgrid processes on climate forcing via the aerosol direct effect. The overall impact is underestimated cooling by aerosols.